2021_10_28 - LG

Updated with schedule and milestones

From: EICSC

eRD111 FY2022 work plan proposal

Forming modules from stitched sensors

The process of taking sensor reticles (even stitched sensor reticles) and integrating them into building block units that are compatible with detector size requirements, electrically and mechanically integrated units, and can be joined together to propagate power and signal lines is a significant effort. In general, a module will consist of a set of sensors mechanically and electrically joined on a flexible PCB with careful silicon positioning and reference markers for further assembly and survey. For large area applications, this work needs to be automated such that the level of personnel effort can be managed. In ALICE ITS-2 upgrade this was accomplished with custom high precision pick-and-place machinery and extensive supply chain management system. The sizes and compositions of the module type(s) together with the reticle size (and number stitched together) dictate a set of possible configurations that need to be evaluated with respect to suitability for forming staves and discs out of these module type(s).

Stave/disc construction

The geometry of the ALICE ITS3-based vertexing layers [1] has to be adapted to the target EIC radii and length, and bending and interconnection techniques and toolings have to be optimized. For the tracking layers, viable ITS2-based design concepts exist for a plausible set of stave designs that can meet the EIC needs. Nevertheless, this is an opportune time to examine other stave concepts that can potentially exceed the ITS2 stave performance. The discs required by the all-silicon design require a full R&D and design effort to reach a viable level of readiness. The effort in these areas will include careful examination of the stave concepts including cooling and mechanical modeling as well as understanding of the assembly requirements for integrating a full set of stave layers into the detector concept. The discs require everything that is needed in the staves as well as layout of the large area reticles onto half-disc concepts and the full mechanical design of half-disc plates with the possible option of cooling using air blown through carbon foam as an option to the water cooling used currently in the conceptual designs.

Additional infrastructure including mechanics and cooling

The mechanical design of the support structures both for the silicon tracking detector package and the tie-in to the global mechanical supports are a work in progress that require continual updating to remain consistent with the needs of the detector, consistency of assembly sequence, and the overall full detector layout. The effort in the cooling will concentrate on verification of the stave and cooling needs consistent with the anticipated ITS3 based sensor dissipation. Different cooling options including the existing water cooling option but also cooling with air forced through carbon foam between the face sheets of the disc plates and possible extension into a stave design if feasible. A first look at alignment and survey needs is also anticipated.

Budget and milestones

Budget

Please note that the budget given below is described in the US DOE system where scientific staff already on grant (staff, postdoc) are not costed as part of the totals presented here but support staff (engineers, technicians, etc.) are costed to the project. The nature of international collaborations invite the possibility that some of this work will be done in institutions that adhere to different funding systems. As such, the numbers presented represent the high limit expected to do the tasks described.

The budget shown below for FY22 is in summary form. A complete set of effort estimates is available upon request via the previously delivered spreadsheet 2020_10_19_EIC_R&D_to_TDR_estimate_with_profile_corrected.xlsx

	Silicon Designer (h)	Mechanical Engineer (h)	Electrical Engineer (h)	Mechanical Technician (h)	Electrical Technician (h)	postdoc (h)	staff (h)	student (h)	materials (k$)	total (k$)
sensor modulization		162.0	93.0	105.0	63.0	156.0	177.0	102.0	6.3	79.5
Staves and Discs		279.0	135.0	162.0	96.0	249.0	231.0	162.0	12.8	140.0
Mechanics, integration and cooling		222.0	60.0	132.0	24.0	144.0	198.0	135.0	10.8	73.9
										381.4

These budget numbers assume labor rates consistent with LBNL labor rates (staff and postdoc are not costed in this formulation) and an overhead of 30% (to be checked).

Milestones

The following milestones are anticipated and shown in the schedule flow..

Milestone Description	Date
report on modules options/optimizations	2022/08/08
report on baseline stave designs	2022/04/27
report on baseline disc designs	2022/06/08
report on simple disc and stave models	2022/12/21 (FY23)
up-to-date silicon tracking CAD models	2022/06/15
report on mechanics conceptual design	2022/07/27
ERD111 report for FY22	2022/09/21

Deliverables

Forming modules from stitched sensors

The FY22 efforts in forming modules from stitched sensors deliverables will include:

1. Study of how to adapt the ITS3 based mechanical and electrical characteristics to the nominal EIC vertexing layer radii based on the available reticle sizes, and optimization of the bending and interconnection techniques for the resulting configuration
2. Study of how to configure sensors into staves and discs based on reticle sizes and possible yield configurations on a 12” wafer.
3. Study of optimizing the number of stitched sensor units into a module composed of an aluminum flex PCB and optimized number of sensors. Flex PCB (aluminium conductor) manufacturing capabilities will play a significant role. Prototype designs may be run as a test fabrication and assessed.
4. The need for tooling to assemble and test sensors in module form will be investigated (this was a very significant part of the ALICE development for ITS2).
5. This will inevitably be a survey effort and will need to be further optimized once yield figures are known. Nevertheless this work is needed to form requirements for the large-area sensor design in a multiple sensor => single readout chaining. This will inform the functionality needed to be built into the forked sensor design.
6. A written report covering this will be delivered.

Staves and Discs

Staves and Discs deliverables for FY22 will be:

1. Conceptual designs with analysis ready to be prototyped.

2. Initial simple prototype ”proof of concept” test pieces to be used in cooling and mechanical testing.
3. Written reports detailing the results and evaluating suitability for final design (parameters will inevitably change, but we need to evaluate the design concepts in the framework of the current knowledge).

Mechanics, integration and cooling

Deliverables for the Mechanics, integration and cooling for the aforementioned FTE composition and level of effort in FY22 will include:

1. Updated and maintained CAD model of evolving silicon tracking detector design in conjunction with EIC project detector constraints including beam pipe, assembly, integration envelopes, etc.
2. Design concepts for the full set of detector supports including cylinders, shells, services channels, connection points to global supports with detector assembly, integration, and connection to services aspects addressed. This will be in written form and in CAD model form.
3. Initial analysis of the design and possibly prototype pieces of the carbon fiber structures involved in the tracking detector as a written report.
4. Analysis of the cooling options for the staves and discs (vertexing layers are an ongoing topic with the ITS3 work). Preliminary design of water cooling options with segmentation and architecture. Investigation into and analysis of using air cooling in a sandwiched carbon foam configuration for staves and discs. All in written report form. If feasible, initial analysis prototypes and results with a report in written form.

Labor Force

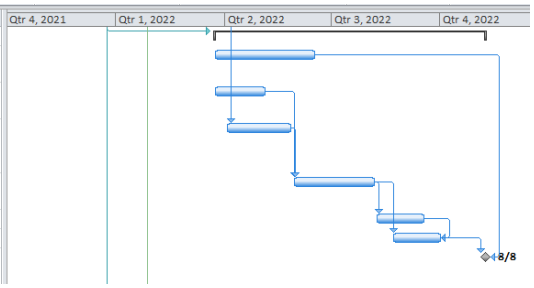
EICSC members will provide the labor force for the above proposed FY22 activity. The breakdown of EICSC institutions involved and a contact persons for the activities is shown in the following table. Please note that the effort table is not yet complete, more institutions will be joining the topics shown and this table will continue to be updated.

Topic	Institutions involved	Contact Person
Forming modules from stitched sensors	INFN Trieste, UK groups (Daresbury, Lancaster, Liverpool, Birmingham), INFN Bari	Giacomo Contin (INFN Trieste) Domenico Elia (INFN Bari) Roy Lemmon (Daresbury)
Staves and Discs	LBNL, LANL, INFN Trieste, INFN Bari, UK groups (Daresbury, Lancaster, Liverpool)	Nikki Apadula (LBNL) Walter Sondhem (LANL) Roy Lemmon (Daresbury)
Mechanics, integration and cooling	LBL, LANL, UK groups, JLAB,	Ernst Sichtermann (LBNL) James Fast (JLAB)

Schedule

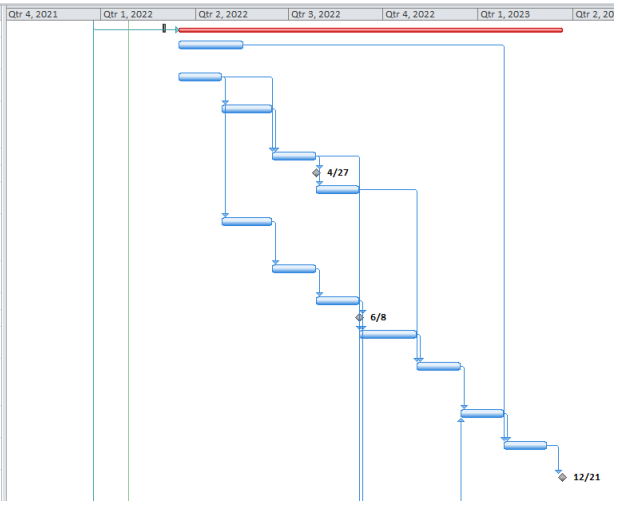
Modules

	Task	Task Name	Duration	Start	Finish	Predecessors
68		**FY22 Modules R&D**	**162 days?**	**Fri 12/24/21**	**Mon 8/8/22**	**1SS+60 days**
69		bending/interconnection validation for vertexing radii	60 days	Fri 12/24/21	Thu 3/17/22	
70		gather pick and place machine data	30 days	Fri 12/24/21	Thu 2/3/22	
71		define requirements using projected reticle size and stave/disc sizes	40 days	Mon 1/3/22	Fri 2/25/22	21
72		assess optimized module composition	50 days	Mon 2/28/22	Fri 5/6/22	71,70
73		assess flex PCB sizes/needs	30 days	Mon 5/9/22	Fri 6/17/22	72
74		assembly/test tooling investigatio	30 days	Mon 5/23/22	Fri 7/1/22	73FF+10 days,72
75		report on modules options/optimizations	1 day?	Mon 8/8/22	Mon 8/8/22	74FS+25 days,69FF+25 days



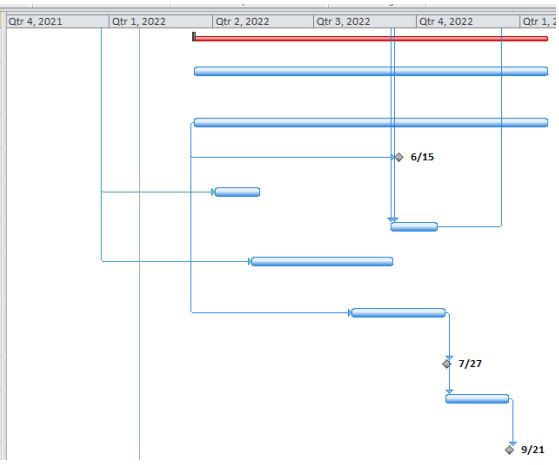
Staves and Discs

	Task	Task Name	Duration	Start	Finish	Predecessors
88		**FY22 staves and discs R&D**	**1 day?**	**Wed 12/1/21**	**Wed 12/1/21**	**1SS+30 days**
89		develop stiffness and vibrational requirements for staves and discs	45 days	Wed 12/15/21	Tue 2/15/22	
90		examine stave options (ITS like, I-beam, etc.)	30 days	Wed 12/15/21	Tue 1/25/22	
91		develop stave configuration options based on likely reticle sizes	35 days	Wed 1/26/22	Tue 3/15/22	90
92		develop baseline stave designs	30 days	Wed 3/16/22	Tue 4/26/22	91,90
93		report on baseline stave designs	1 day?	Wed 4/27/22	Wed 4/27/22	92
94		FEA analysis of stave/I-beam/etc designs	30 days	Wed 4/27/22	Tue 6/7/22	92
95		examine disc options (stave based, plate based, etc.) based on likely reticle sizes	35 days	Wed 1/26/22	Tue 3/15/22	90
96		develop disc configuration options based on reticle sizes	30 days	Wed 3/16/22	Tue 4/26/22	95
97		develop baseline disc designs	30 days	Wed 4/27/22	Tue 6/7/22	96
98		report on baseline disc designs	1 day?	Wed 6/8/22	Wed 6/8/22	97
99		FEA analysis of disc conceptual designs	40 days	Wed 6/8/22	Tue 8/2/22	92,97
100		procure materials for simple mockups of baseline stave and disc designs	30 days	Wed 8/3/22	Tue 9/13/22	99,94
101		fabricate simple disc andstave mechanical models	30 days	Wed 9/14/22	Tue 10/25/22	100,119
102		test simple disc and stave models (mechanical properties, cooling)	30 days	Wed 10/26/22	Tue 12/6/22	101,89
103		report on simple disc and stave models	1 day?	Wed 12/21/22	Wed 12/21/22	102FS+10 days



Mechanics, integration and cooling

	Task	Task Name	Duration	Start	Finish	Predecessors
114		**FY22 mechanics, cooling, infrastructure R&D**	**1 day?**	**Wed 12/15/21**	**Wed 12/15/21**	
115		update CAD models based on mechanics/stave/disc developments	225 days	Wed 12/15/21	Tue 10/25/22	
116		integrate services models into CAD as options become avialable	225 days	Wed 12/15/21	Tue 10/25/22	
117		up-to-date silicon tracking CAD models	1 day?	Wed 6/15/22	Wed 6/15/22	116SS+130 days
118		review carbon foam studies for cooling options	30 days	Mon 1/3/22	Fri 2/11/22	1SS+60 days
119		integrate cooling optinos into stave/disc prototype designs	30 days	Wed 6/8/22	Tue 7/19/22	97,92
120		develop conceptual designs for insertion clamshell mechanisms, detector half-shell mechanics	90 days	Fri 2/4/22	Thu 6/9/22	1SS+90 days
121		develop conceptula design for shells, cones, flanges, mounting rings	60 days	Wed 5/4/22	Tue 7/26/22	116SS+100 days
122		report on mechanics conceptual design	1 day?	Wed 7/27/22	Wed 7/27/22	121
123		FEA analysis of shells and cones to determine mechanical parameters needed	40 days	Wed 7/27/22	Tue 9/20/22	121
124		ERD111 report for FY22	1 day?	Wed 9/21/22	Wed 9/21/22	123



References

[1] ALICE Collaboration, Letter of Intent for an ALICE ITS Upgrade in LS3, https://cds.cern.ch/record/2703140, CERN-LHCC-2019-018, LHCC-I-034 (2019).